Peracarid crustacean assemblages of benthic soft sediments around Moreton Island, Queensland

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ABSTRACT

The potential for differences in the benthic peracarid assemblage composition of soft sediments around Moreton Bay was examined. Peracarid assemblages are described from van Veen grab samples collected at 26 stations during the Moreton Bay workshop of February 2005. The samples were all from soft sediments, at 6–40 m depth. Assemblages were analysed at the family level for all peracarids, at the genus level for cumaceans and tanaidaceans, and at the species level for tanaidaceans only (using data from a further 15 stations). Five main station groupings were identified at the family level by multivariate analysis. While an indication of association with sediment type and, by inference, organic content, was indicated, neither sampling gear nor depth seemed to influence the pattern. Analysis at generic level for cumaceans and tanaidaceans showed a distinction in the stations east of Moreton and North Stradbroke Islands by depth. However, the inclusion of polytypic genera introduces confusion to the interpretation. Analysis of the tanaidaceans at the specific level, which allowed inclusion of further sampling stations on muddier substrata, showed more detailed community distinctions based on substratum, depth and, by association, on geography. Microhabitat development off the South Passage is discussed. With the intrageneric habitat-distinctions demonstrated in the tanaidacean component of the community, it is clear that, while analysis at higher taxon levels shows some gross trends in the community distribution in relation to substratum type, the added detail provided by a species-level analysis affords a more comprehensive, more logical, and explicable interpretation. These results show that analysis of assemblages of the Peracarida alone does allow interpretation of habitat-associations, and thus biotopes. ❑ *Crustacea, Peracarida, Queensland, Australia, Amphipoda, Cumacea, Tanaidacea, assemblage, community, depth, substratum, taxonomic sufficiency.*

Moreton and North Stradbroke Islands separate Moreton Bay, a subtropical Pacific water mass, from the main ocean (Fig. 1). Moreton Bay is also a complex estuarine system into which the Brisbane, Logan–Albert, Pine and Caboolture Rivers drain. At times Moreton Bay has almost full oceanic salinity throughout, at other times a large proportion of freshwater is present particularly in the western part (Milford & Church 1977).

Oceanic water enters the Bay on each tide, mainly from the north, flooding in a south-westerly direction predominantly through the Main Passage and Pearl Channel (Milford & Church 1977). Some water enters from the (eastern) South Passage flooding westwards through the Rous Channel and southwards through the Rainbow Channel. At half-tide, surface currents of more than 5.5 km/hr were observed at the

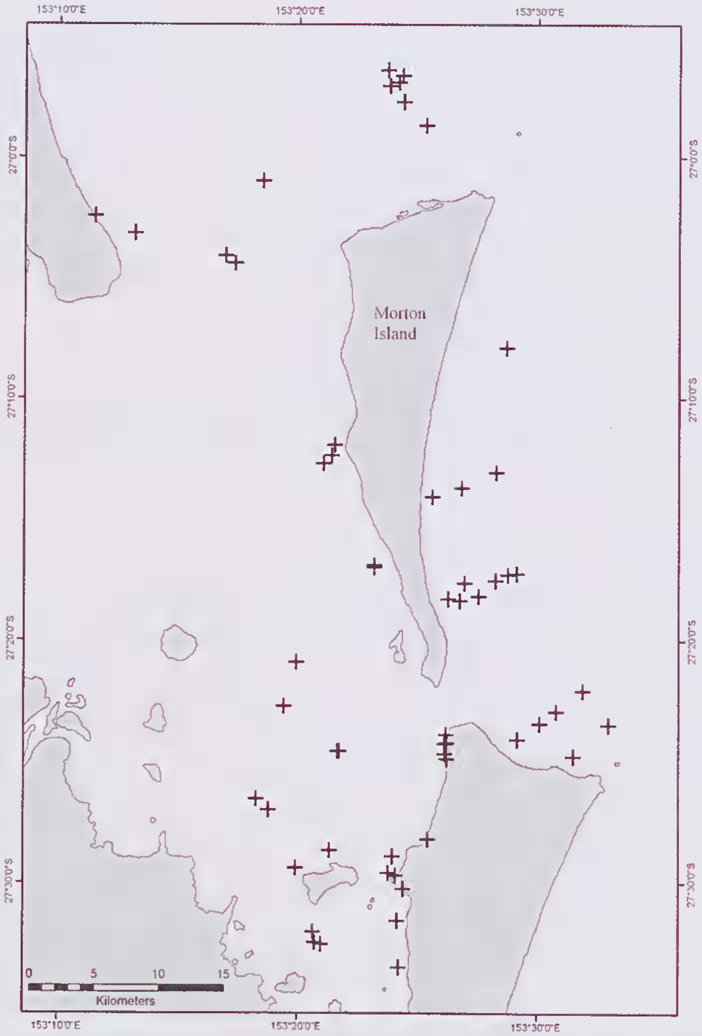

FIG. 1 Location of stations sampled for Peracarida Febuary 2005.

Bay entrance (Stephenson *et al*. 1970). On the ebb tide, the flow through the narrow South Passage, between Moreton and North Stradbroke Islands, is particularly rapid and turbulent.

Hutchings (1999) contrasts other types of protected water that can fluctuate in salinity to estuaries, embayments and coastal lagoons. Moreton Bay is considered an embayment, as are Port Philip Bay, Westernport Bay, Jevis Bay and Botany Bay along the eastern Australian coast. These have similar hydrographic conditions to the mouths of large rivers. They are often shallow and with limited stratification as wind-generated waves ensure good mixing. Typically the embayments are fully marine except during periods of heavy rain when salinity falls, as has been recorded for Moreton Bay by Stephenson *et al*. (1977).

According to Stephenson *et al*. (1970) mud-scouring action causes the corrugated nature of the north-eastern bay. Maxwell (1970) analysed sediment samples in Moreton Bay. We did not undertake sediment analyses but a description of the sediment was made for each sample.

Moreton Bay is relatively well-studied scientifically; biological samples have been taken and analysed since the mid-1950s (e.g. Slack-Smith 1960), and macrobenthic communities were a particular focus of Stephenson and his students and colleagues during the 1970s and 1980s (see

Table 1. Summary information for the study sites sampled for Peracarida off Moreton Island considered in the family analysis. Abbreviations: vV = van Veen; lavV=long arm van Veen

Sample	Feb 2005	Lat	Long	Depth (m)	‰	Temp.	Gear	Habitat
16.1	16	26°58.68′S	153°25.32′E	15.8	35	28.7	vV	clean medium sand
16.2	16	26°57.70′S	153°24.39′E	18	35	28.6	vV	clean medium sand
16.3	16	26°56.62′S	153°24.35′E	27.9	35	28.6	vV	clean medium sand with shell breccia
16.4	16	26°57.05′S	153°23.81′E	23.6	35	28.3	vV	clean medium sand with shell breccia
16.5	16	26°56.38′S	153°23.73′E	41.3	35	28.8	vV	muddy medium sand with shell breccia and holothurians
16.6	16	26°56.89′S	153°24.19′E	23.6	35	28.3	vV	clean medium sand with shell breccia
16.7	16	27°01′S	153°18.5′E	6.6–10.2	35	27.6	vV	North of Moreton I., clean well-sorted sand.
17.1	20	27°32.46′S	153°20.74′E	3.1	33	28	lavV	Banana Bank (sandy mud with some seagrass)
19.1	19	27°24.10′S	153°29.18′E	10.7	35	28	lavV	clean medium sand
19.2	19	27°23.46′S	153°30.08′E	20			lavV	clean medium sand
19.3	19	27°22.95′S	153°30.79′E	26.6			lavV	slightly muddy medium sand with holothurians
19.4	19	27°22.10′S	153°31.91′E	35.5		27.9	lavV	slightly muddy medium sand with holothurians,
19.5	19	27°18.29′S	153°26.28′E	11		28.5	lavV	East of S Moreton Island, clean medium sand
19.6	19	27°17.65′S	153°26.95′E	19.4			lavV	clean medium sand with some shell, ophiuroids
19.7	19	27°17.54′S	153°28.26′E	29		28.1	lavV	clean medium sand with some shell, dense holothurians
22.2	22	27°17.26′S	153°29.141′E	40			lavV	medium sand with plethora of holothurians & organics
22.3	22	27°18.19′S	153°27.56′E	20.6			lavV	clean medium sand
22.4	22	27°18.37′S	153°26.77′E	9.9			lavV	clean medium sand
22.5	22	27°13.07′S	153°28.29′E	35.6			lavV	coarse sand and shell with holothurians
22.6	22	27°13.70′S	153°26.84′E	25.2			lavV	cleaner medium sand with sparse holothurians
23.1	23	27°12.70′S	153°21.07′E	2.8	35	28.2	lavV	fine sand with shell, Nepthys
23.2	23	27°12.37′S	153°21.42′E	16.8			lavV	fine sand with shell, Nepthys
23.4	23	27°04.41′S	153°17.36′E	7.2			lavV	clean sand with polychaetes
23.5	23	27°04.10′S	153°16.95′E	8.5			lavV	medium sand with shell
23.6	23	27°03.17′S	153°13.17′E	10.2			lavV	medium sand with coarse shell breccia, callianassids, ophiuroids
23.7	23	27°02.46′S	153°11.49′E	8.3		28.8	lavV	coarse sand with gorgonians, pebbles, crabs, callipallenids

Table 2. Breakdown of average similarity into contributions from each family of the peracarid assemblage sampled; families are ordered in decreasing contribution. A= Average Abundance, see text for meaning of remaining symbols.

Group/Family	A	Si	Si/SD	Contrib%	Cum%
Group A: Average similarity= 33.33%					
Bodotriidae	52.38	33.33		100	100
Group B: Average similarity= 53.11%					
Platyschnopidae	64.83	49.11	2.64	92.46	92.46
Phoxocephalidae	4.33	2.01	2	3.79	96.25
Group C: Average similarity= 51.99%					
Platyschnopidae	19.78	16.41	22.9	31.57	31.57
Phoxocephalidae	16.69	13.8	4.43	26.54	58.11
Photidae	7.86	7.26	11.4	13.97	72.09
Urohaustoridae	11.43	7.01	1.34	12.49	85.58
Amphipoda Fam. B	6.41	5.2	3.53	10	95.58
Group D: Average similarity= 50.13%					
Parapseudidae	29.01	17.28	4.04	34.48	34.48
Platyschnopidae	19.4	12.35	1.44	24.63	59.1
Oedicerotidae	18.52	9.26	0.58	18.47	77.57
Urohaustoridae	13.1	6.61	1	13.19	90.77
Bodotriidae	5.86	2.78	0.58	5.54	96.31
Group E: Average similarity= 56.68%					
Urohaustoridae	55.08	44.42	3.85	78.37	78.37
Phoxocephalidae	13.36	4.57	0.62	8.06	86.43
Platyschnopidae	8.59	3.01	0.57	5.3	91.73
Lysianassidae	7.17	2.37	0.57	4.18	95.91

Stephenson 1980a–c; 1981; Stephenson & Cook 1977, 1979; Stephenson & Sadacharan 1983; Stephenson *et al.* 1970, 1974, 1976, 1977, 1978). Such studies led to taxonomic revisionary work on a number of groups (e.g., Brachyura by Campbell & Stephenson 1970), and while some peracarids have also received attention (e.g., cumaceans by Tate & Greenwood 1996a, b; and the Tanaidacea by Bamber 2008), diverse peracarid groups such as the Isopoda and Amphipoda remain neglected, and the literature identifications mostly cursory.

In the present paper we focused on peracarid crustaceans sampled in Moreton Bay as well as in open Pacific waters to the east of North Stradbroke and Moreton Islands.

The sample area extends from south of Peel Island to 10 km north of Moreton Island, and from close to the shore of Bribie Island to as far west as Flat Rock, see Table 1 and Fig. 1. The sampled area extends 50 km from north to south and 25 km from east to west. The sampling area to the north and east of Moreton Island is open to the Pacific Ocean, whereas the area east of Moreton and Stradbroke Islands, Moreton Bay itself, is sheltered between the Australian mainland and these long islands.

METHODS

FIELD AND LABORATORY

In February 2005, over one hundred stations were sampled of which 26 sublittoral stations were sampled quantitatively and thus considered for this analysis. The depth range of the samples studied was 6 to 40 m. Samples were collected using a small van Veen grab, surface sampling area 0.1 m², and a long-arm van Veen grab with a surface sampling area of 0.2 m². Faunal samples were washed on a 0.5 mm mesh. In the laboratory the faunal samples were rinsed in tap water to

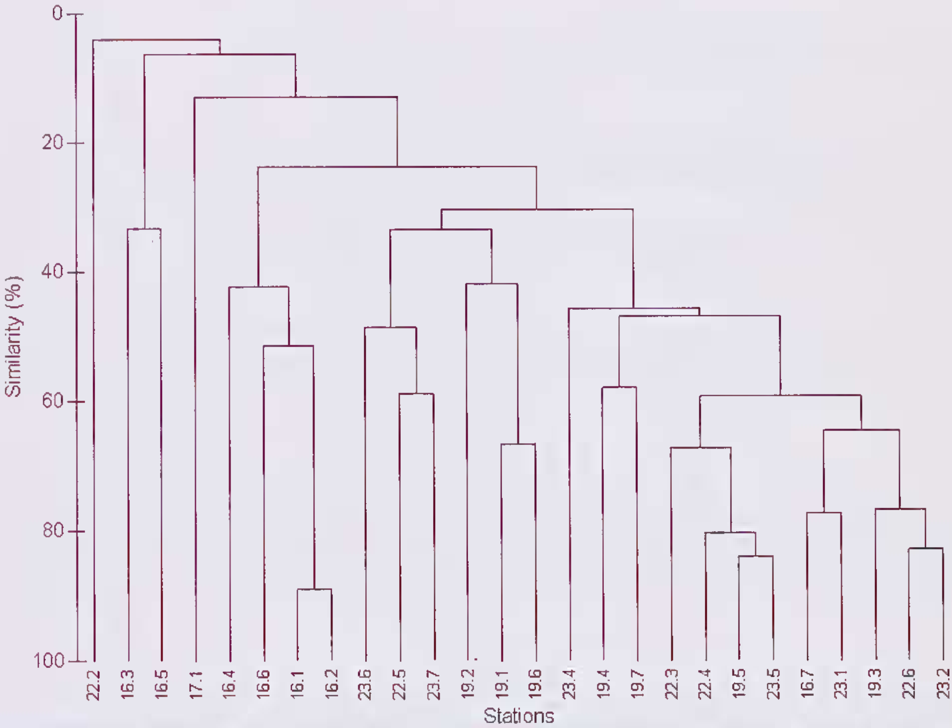

FIG. 2. Dendrogram of cluster analysis of peracarid families off Moreton Island based on the Bray-Curtis similarity matrix of family abundances.

relax the specimens, the fauna picked out under a dissecting microscope, sorted to major taxa and transferred to 95% ethanol or 4% buffered formalin.

Additional tanaidacean material was made available from a contemporaneous survey of the southern part of Moreton Bay by Davie *et al.* (2010, this volume); this survey sampled 15 stations by van Veen grab, five replicates per station. The tanaidaceans from all of these samples were made available for analysis.

The peracarids were identified at least to family level; cumaceans were identified to genus, and tanaidaceans to species (e.g. Bamber, 2008). The Amphipoda are deposited at the NIWA Marine Invertebrate Collection (NIC), Wellington, the Isopoda at NIC and the Museum Victoria, Melbourne and the Tanaidacea and Cumacea at the Queensland Museum, Brisbane, and the Natural History Museum, London. Mysidacea were very rare, and were not analysed.

DATA ANALYSIS

Multivariate analysis of the data was performed using the PRIMER (Clarke & Warwick 2001) and CAP (Pisces Conservation Ltd) suites of programs. Taxa represented by only one individual were omitted and stations where only one taxon was sampled were also omitted from the multivariate analysis. The resulting data matrix for the full peracarid analysis included 1224 individuals belonging to 36 families from 26 of 29 van Veen stations (73% of the peracarids collected). A triangular matrix of similarities between samples was derived using the Bray-Curtis similarity coefficient. Similarities in assemblage composition between the stations were displayed by constructing a dendrogram and ordination from the similarity matrix. Clustering was by a hierarchical agglomerative method using group-average linking. Ordination was by non-metric multidimensional scaling (MDS). The main taxa contributing to the average similarity within a group or average dissimilarity between groups were assessed using the Similarity Percentage routine (SIMPER).

Similar analyses were conducted at the genus level for cumaceans and tanaidaceans, and at the species level for tanaidaceans. For the

Table 3. Breakdown of average dissimilarity between groups into contribution of each family of the peracarid assemblage sampled. A=Average Abundance, see text for meaning of remaining symbols.

Groups/Families	A	A	A Diss	Diss/ SD	Con-trib %	Cum %
Groups A+B. Average dissimilarity = 94.46%	Group B	Group A				
Platyschnopidae	64.83	2.08	31.37	2.64	33.2	33.21
Bodotriidae	2.35	52.38	25.01	2.42	26.5	59.69
Ischyroceridae	0	14.29	7.14	0.94	7.56	67.25
Synopiidae	12.86	0	6.43	0.54	6.81	74.06
Aoridae	0	12.5	6.25	0.94	6.62	80.68
Groups B+E. Average dissimilarity = 79.53%	Group B	Group E				
Platyschnopidae	64.83	8.59	28.12	2.31	35.4	35.36
Urohaustoridae	6.6	55.08	24.24	2.42	30.5	65.84
Synopiidae	12.86	0.31	6.51	0.58	8.18	74.02
Phoxocephalidae	4.33	13.36	6.16	0.89	7.74	81.76
Groups A+E. Average dissimilarity = 95.52%	Group A	Group E				
Urohaustoridae	0	55.08	27.54	3.09	28.8	28.83
Bodotriidae	52.38	1.67	25.36	2.58	26.5	55.38
Ischyroceridae	14.29	1.67	25.36	2.58	26.5	55.38
Phoxocephalidae	0	13.36	6.68	0.84	6.99	69.85
Aoridae	12.5	0	6.25	0.98	6.54	76.39
Groups B+D. Average dissimilarity = 69.95%	Group B	Group D				
Platyschnopidae	64.83	19.4	22.71	1.82	32.5	32.47
Parapseudidae	0	29.01	14.51	1.83	20.7	53.21
Oedicerotidae	2.2	18.52	8.89	1.52	12.7	65.92
Synopiidae	12.86	2.38	7.03	0.66	10	75.97
Urohaustoridae	6.6	13.1	5.7	1.37	8.15	84.12
Groups A+D. Average dissimilarity = 84.95%	Group A	Group D				
Bodotriidae	52.38	5.86	23.26	2.18	27.4	27.38
Parapseudidae	0	29.01	14.51	1.75	17.1	44.45
Platyschnopidae	2.08	19.4	8.66	1.74	10.2	54.65
Oedicerotidae	8.33	18.52	7.87	1.46	9.26	63.91
Ischyroceridae	14.29	1.23	7.14	0.99	8.41	72.32
Urohaustoridae	0	13.1	6.55	1.5	7.71	80.02
Aoridae	12.5	0	6.25	0.91	7.36	87.38
Groups D+E. Average dissimilarity = 70.99%	Group D	Group E				
Urohaustoridae	55.08	13.1	20.99	2.16	29.6	29.57
Parapseudidae	3.62	29.01	12.71	1.6	17.9	47.47
Oedicerotidae	1.03	18.52	9.09	1.46	12.8	60.28
Platyschnopidae	8.59	19.4	7.12	1.53	10	70.3
Phoxocephalidae	13.36	2.16	6.21	0.83	8.75	79.05
Lysianassidae	7.17	2.16	3.4	0.94	4.79	83.84
Groups B+C. Average dissimilarity = 69.75%	Group B	Group C				
Platyschnopidae	64.83	19.78	22.53	1.91	32.3	32.29

Table 3 continued ...

Groups/Families	**A**	**A**	**A Diss**	**Diss/ SD**	**Con-trib %**	**Cum %**
Synopiidae	12.86	0	6.43	0.55	9.22	41.51
Phoxocephalidae	4.33	16.69	6.18	2.39	8.86	50.37
Urohaustoridae	6.6	11.43	5.19	1.73	7.45	57.82
Photidae	0	7.86	3.93	10.16	5.64	63.46
Groups A+C. Average dissimilarity = 93.41%	Group A	Group C				
Bodotriidae	52.38	2.48	24.95	2.38	26.7	26.71
Platyschnopidae	2.08	19.78	8.85	3.26	9.47	36.18
Phoxocephalidae	0	16.69	8.35	4.25	8.94	45.12
Ischyroceridae	14.29	0	7.14	0.91	7.65	52.76
Aoridae	12.5	0	6.25	0.91	6.69	59.46
Urohaustoridae	0	11.43	5.71	1.89	6.12	65.57
Groups C+E. Average dissimilarity = 68.13%	Group C	Group E				
Urohaustoridae	55.08	11.43	21.83	2.35	32	32.03
Phoxocephalidae	13.36	16.69	6.94	1.58	10.2	42.23
Platyschnopidae	8.59	19.78	6.71	1.77	9.85	52.08
Lysianassidae	7.17	0	3.58	0.84	5.26	57.34
Photidae	0.96	7.86	3.45	3.01	5.07	62.4
Groups C+D. Average dissimilarity = 66.49%	Group C	Group D				
Parapseudidae	29.01	2.48	13.26	1.64	20	19.95
Oedicerotidae	18.52	0	9.26	1.33	13.9	33.88
Phoxocephalidae	2.16	16.69	7.27	3.5	10.9	44.81
Platyschnopidae	19.4	19.78	4.36	1.73	6.56	51.37
Urohaustoridae	13.1	11.43	4.05	1.36	6.08	57.46
Photidae	0.93	7.86	3.47	4.35	5.22	62.67
Leptocheliidae	0	6.67	3.33	0.67	4.32	72.01

latter, the station data from the survey of Davie *et al.* (2010) were standardised as the integer (rounded up) of the mean of the five replicates per station; a further 13 stations were thus included in the dataset.

RESULTS

PERACARID FAUNA

In total 1224 peracarids were sampled in the van Veen samples, the bulk (1098) belonging to 24 families of Amphipoda. The most numerous family was the Urohaustoridae (359), followed by Platyischnopidae (218), the families Phoxocephalidae and Synopiidae were also represented by more than 100 specimens. Of the non-amphipod taxa the tanaidacean family Parapseudidae was most abundant, with nearly 50 specimens caught.

MULTIVARIATE ANALYSIS

Family-level analysis of all Peracarida

The cluster analysis for the 26 grab stations at the family level is shown in the dendrogram (Fig. 2). The peracarid family groups revealed are shown on the map (Fig. 3)

The dendrogram of the station data clearly illustrates the pattern in assemblage composition. The four stations north of Moreton Island group closely; with exception of these northern stations, the grouping of the sites does not reflect their geographic separation.

SIMPER analysis indicated that the average similarity in assemblage composition within groups ranged from 50% (group D) to 57% (group E) and that individual taxa within groups contributed from 2–49% to the similarities observed (Table

2). Taxa that contributed the most to within-group similarity and/or which were characterising taxa (i.e., those for which the ratio of Sim/SD was relatively high) for each group varied, although some taxa were 'typical' for a number of groups. The peracarid assemblages of group B and group C were primarily characterised by the amphipod family Platyischnopidae. Group D was primarily characterised by the tanaid family Parapseudidae. The amphipod family Urohaustoridae characterised group E.

Simper analysis also indicated the individual taxa that contributed the most to the dissimilarity and/or discriminate between the different groups (i.e. the ratio of Diss/SD is relatively high) (Table 3). Results show that, overall, the two amphipod families Platyischnopidae and Urohaustoridae and the tanaid family Parapseudidae have a large contributory influence on the dissimilarities observed between groups (dissimilarity contributions over 10%). The dissimilarities observed between groups are detailed below (see Table 2 for pairwise comparisons of dissimilarity between all groups). The dissimilarities between groups ranged from 66% (between C and D) to 95% (between A and E).

Groups A and E show the highest dissimilarity. Platyischnopidae are dominant in group A, but not in group E, whereas Urohaustoridae are present in group E, but not in group A. Average dissimilarity was 70% between groups B and D. The tanaid family Parapseudidae mainly discriminated between the two groups, being only present at group D. The average dissimilarity between groups D and E is 71%. Urohaustoridae are abundant in group E, whereas the tanaidaceans of the Parapseudidae, the amphipods of the Oedicerotidae and Platyischnopidae and the cumaceans are more abundant in group D. The average dissimilarity between B and C is 70%, mainly discriminated by the amphipod family Photidae which occurred only in group C, resulting in their extraordinarily high Diss/SD of 10.16. The groups E and C, located east and west of Moreton Island, show an average dissimilarity of 68%. Again based on the high abundance of Urohaustoridae in group E, as well as Photidae, Platyischnopidae and Phoxocephalidae being more dominant in group C. The average dissimilarity between groups D and C is based on eight families, Photidae showing the highest Diss/SD of 4.35.

Genus-level analysis of Cumacea & Tanaidacea

Figure 4 shows the similarity clustering of stations based on the thirteen genera of the Tanaidacea and Cumacea which were available for analysis. This shows a more structured separation of assemblages. Group 4A, characterised by the tanaidacean genus *Remexudes*, is of the shallower sands of the Pacific Coast (stations within groups D and E of Figs 2, 3). Group 4B comprises stations of the deeper Pacific-coast waters, characterised by the tanaidacean genus *Bathytanais*, the cumacean genus *Dicoides* and many other of the cumacean genera. Group 4C comprises some less-characterised stations on the east coast plus those on muddier, more heterogeneous substrata within Moreton Bay itself, the genera *Pakistanapseudes* (Tanaidacea) and *Cyclaspis* (Cumacea) dominating.

The generic-level interpretation, although more restricted in both taxa and stations, is thus offering further interpretation on the assemblage distribution by habitat, with depth clearly a factor as well as substratum.

The genus-level analysis was expanded for the Tanaidacea by the inclusion of the thirteen additional southern Moreton Bay stations. Figure 5 shows the resulting dendrogram. Group 5A is the same as group 4A of Fig. 4, the stations of the shallower sands of the Pacific Coast. Group 5B includes the deeper sand stations of group 4B (Fig. 4) but here they are associated with a number of shallower stations on muddier substrata within the southern part of Moreton Bay. Similarly group 5D associates the northern and southern Moreton Bay stations. This result implies that, with a wider range of habitat, there is some breakdown of assemblage distinction when restricted to the generic level.

Species-level analysis of Tanaidacea

All the tanaidaceans collected have been distinguished to species (see Bamber 2008). In addition, the broad survey of the southern part of Moreton Bay by Davie *et al.* (2010) produced further quantitative data from van Veen grab samples for the tanaidaceans, to species level. Thus, the wider geographic/habitat interpretation was investigated by analysis of the distribution of the Tanaidacea at the species-level.

The fifteen species analysed, and their familial affiliations, are shown in Table 4.

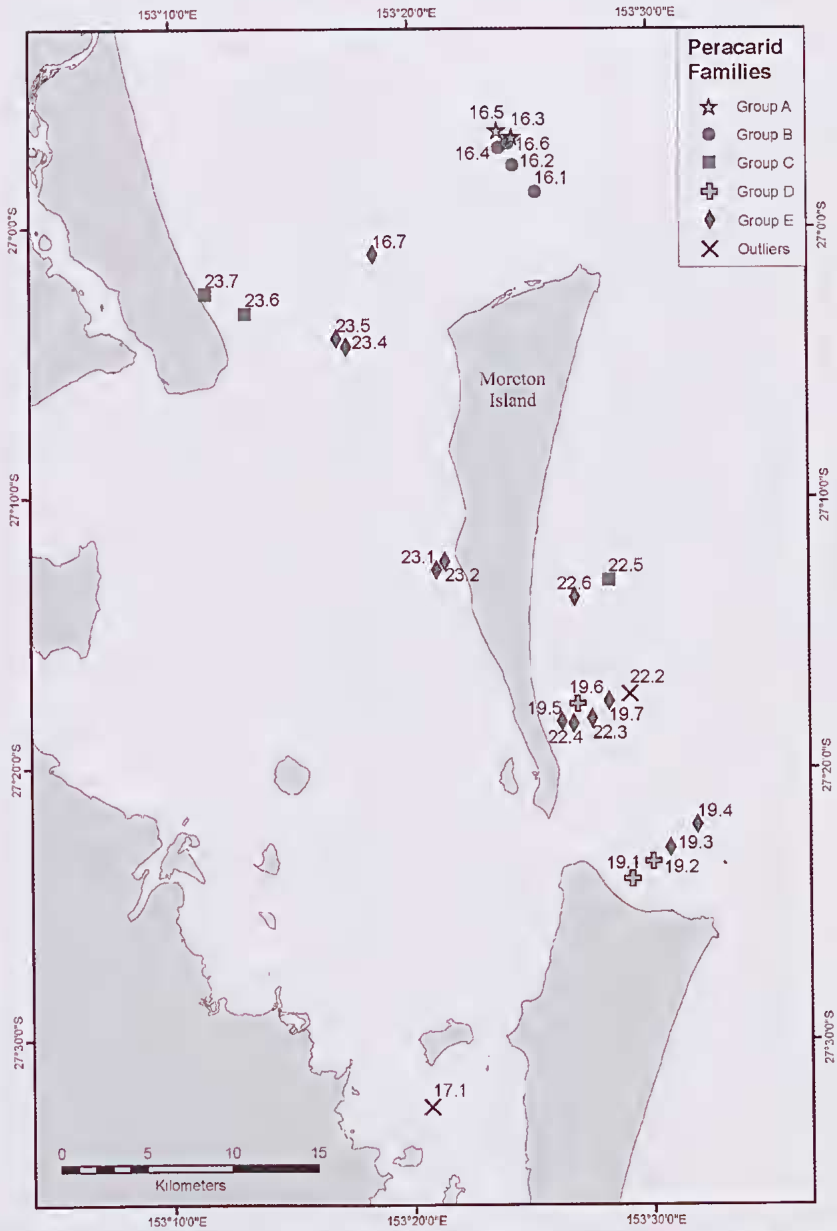

FIG. 3. Study region with groups resulting from peracarid family cluster analysis.

Figures 6 and 7 show the clustering of stations from this analysis. Figure 8 shows the reciprocal clustering of the species.

There is a now clear distinction between stations well within Moreton Bay (groups 6D and 6E) and those outside (groups 6A to 6C). In addition, the stations within the Bay separate into those on seagrass beds in muddy substrata, characterised by *Transkalliapseudes banana* (group 6D; station 17.1 of the family-level analysis is the same location as station 10 within this dataset), and those on sandier substrata (group 6E), characterised by *Whiteleggia stephensoni* and *Pakistanapseudes australianus*.

The stations peripheral to and outside Moreton Bay are distinguished into three groups, those of the shallower sands of the Pacific Coast (group 6A, identical to group 4A above), characterised by *Remexudes toompani* with sparse *Pakistanapseudes perulpa*, those of the deeper Pacific waters

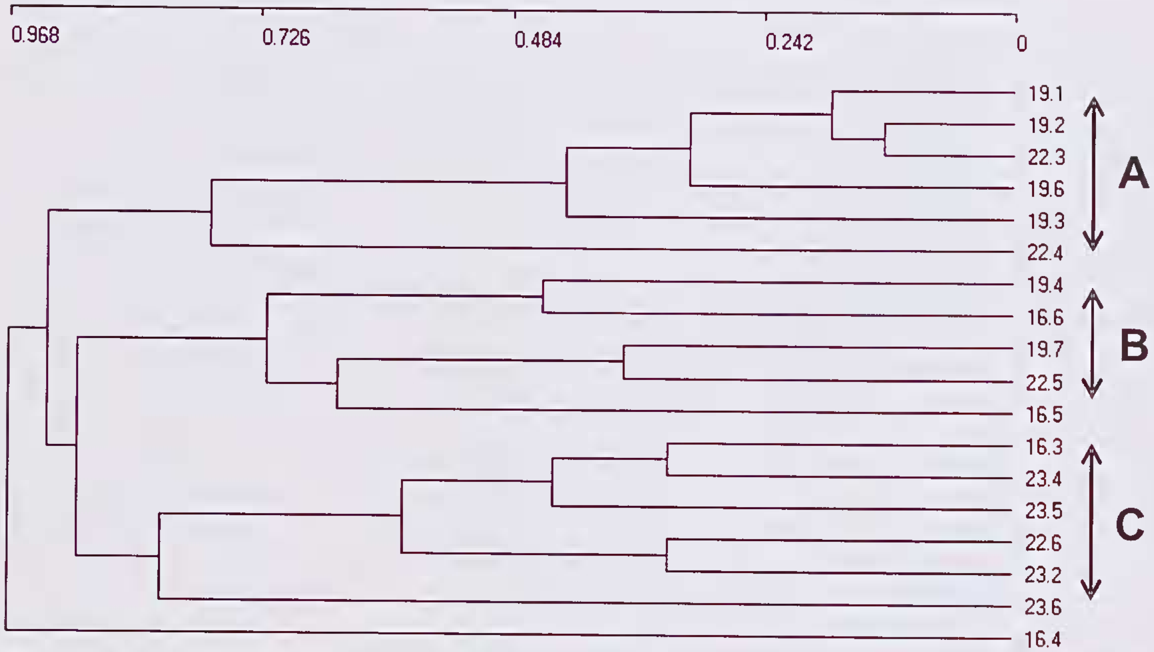

FIG. 4. Dendrogram of cluster analysis of Tanaidacea and Cumacea at genus level off Moreton Island.

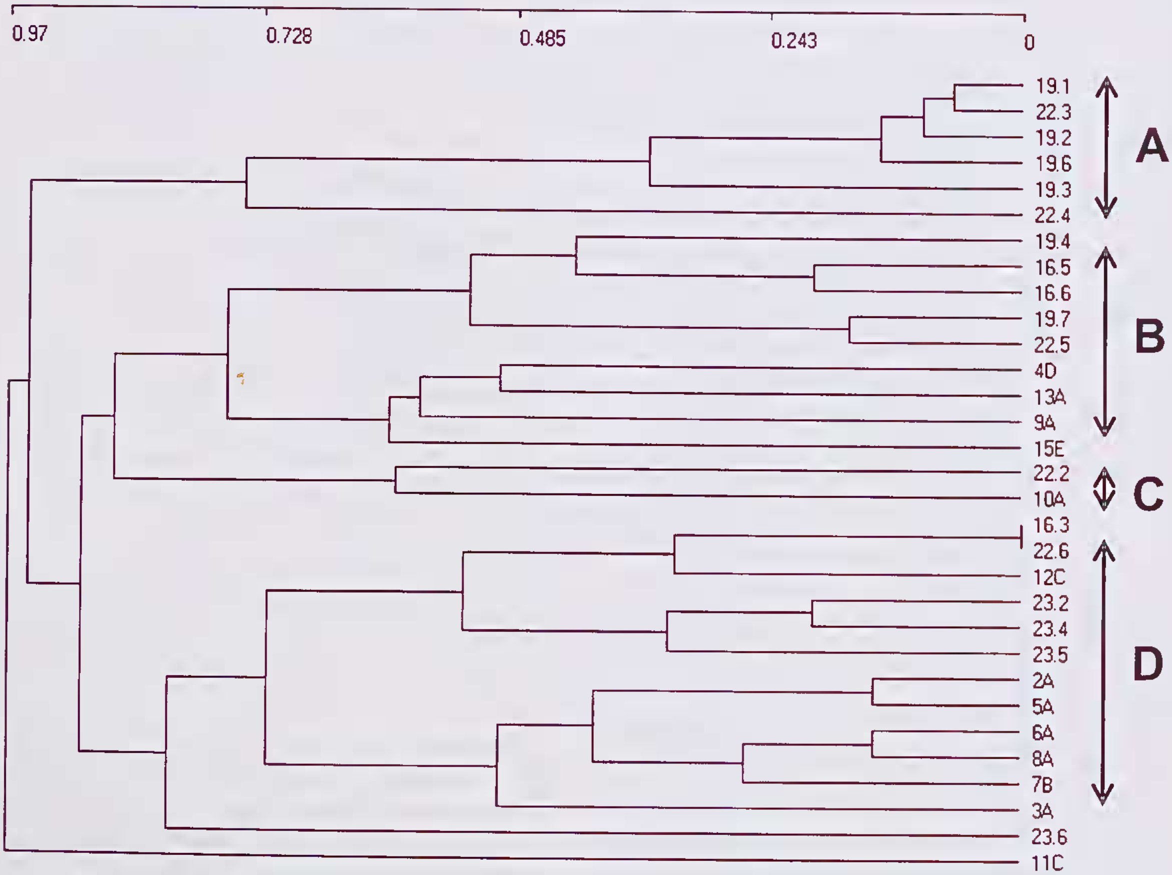

FIG. 5. Dendrogram of cluster analysis of Tanaidacea across the whole area sampled at genus level.

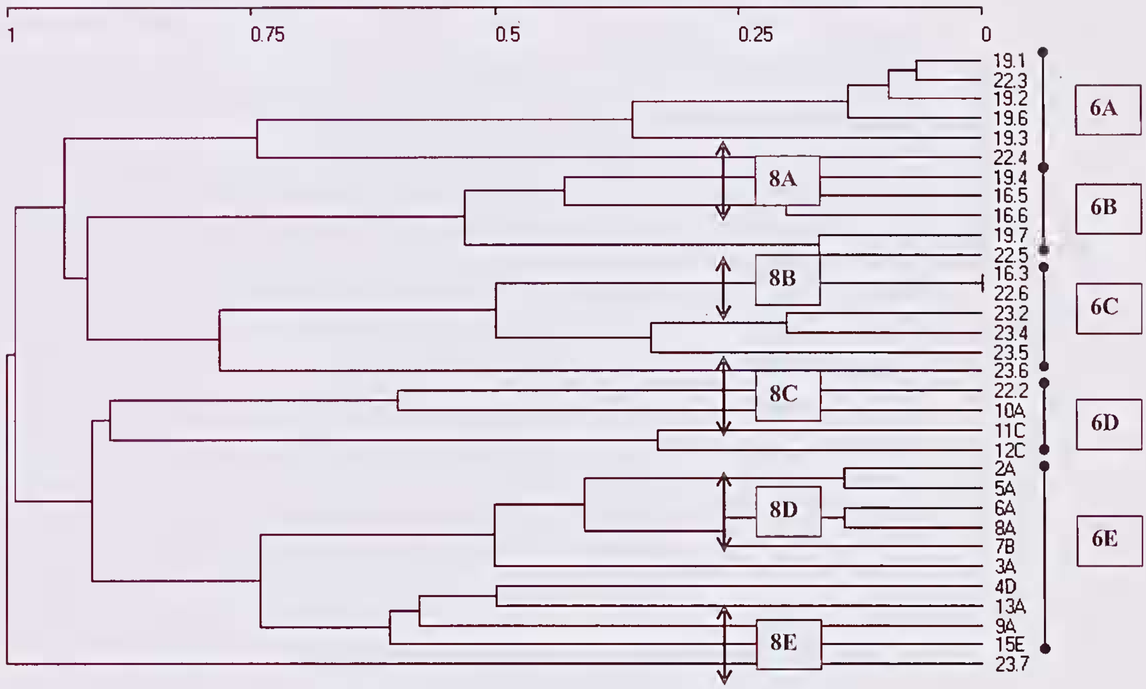

FIG.6. Dendrogram of Tanaidacea across the whole area sampled at species level.

(group 6B, identical to group 4B above), characterised by *Bathytanais bathybrotes*, and the shallower 'northern' stations around Moreton Island (group 6C, identical to group 4C above), characterised by *Pakistanapseudes perulpa*. That these groups relate to those of the genus-level analysis is not surprising, as the genera concerned were monotypic in this analysis.

The species clustering (Fig. 8) confirms these groupings. The three species of group 8E were present only sparsely, and separate as they occur within southern Moreton Bay at stations where *Whiteleggia stephensoni* density is sparse. Only *Antiplotanais coochimudlo* (occasionally sympatric with and thus confusing the linkage of *Bathytanais bathybrotes*) and *Konarus cheiris* occur both offshore and within the Bay.

These analyses at the species level confirm a separation of the fauna by depth, by geography, and by substratum. Further, they demonstrate that this separation is clearly shown at the species level, rather than the generic level (each of the two species of each of *Pakistanapseudes*, *Bathytanais* and *Leptochelia* separate fully), and less so at the family level (see Table 4).

DISCUSSION

Results of the present study of the marine peracarids of Moreton Island, support the hypothesis that there is a difference in peracarid composition around the Island.

Depth showed no significant effect on the station assemblage at the family level (Figs 2, 3). Even though stations of group B were located deeper than 20 m, and the two stations of group A were taken at very similar depth, 16–20 m, the depth of the stations of groups C varies from 8–37 m and group D extends from 11–20 m. The depth of group E, comprising 12 stations, extends from 7–35 m.

There are potential logistical limitations on the techniques herein. Owing to our inconsistent sampling methods such as grabs, dredges, hand collections and trowels, only peracarids from the grabs have been considered for the multivariate analysis. The van Veen grab sampled 0.1 m^2 whereas the long-arm van Veen grab sampled 0.2 m^2. Even though groups A and B only include stations sampled by the van Veen grab and groups C and D only include stations sampled by the long armed van Veen grab,

Table 4. Tanaidaceans used in the multivariate assemblage analyses, with higher taxonomy.

Suborder	Family	Species
Apseudomorpha	Apseudidae	*Gollumudes larakia* (Edgar, 1997)
	Apseudidae	*Bunakenia (E.) anomala* Guţu, 2006
	Whitelegiidae	*Whiteleggia stephensoni* Boesch, 1973
	Kalliapseudidae	*Transkalliapseudes banana* Bamber, 2008
	Parapseudidae	*Remexudes toompani* Błażewicz-Paszkowycz & Bamber,2007
	Parapseudidae	*Pakistanapseudes perulpa* Błażewicz-Paszkowycz & Bamber,2007
	Parapseudidae	*Pakistanapseudes australianus* Guţu, 2006
Tanaidomorpha	Anarthruridae	*Tanaopsis canaipa* Bamber, 2008
	Leptocheliidae	*Leptochelia guduroo* Bamber, 2008
	Leptocheliidae	*Leptochelia opteros* Bamber, 2008
	Leptocheliidae	*Pseudoleptochelia fairgo* Bamber, 2005
	Leptocheliidae	*Konarus cheiris* Bamber, 2006
	Paratanaidae	*Bathytanais bathybrotes* (Beddard, 1886)
	Paratanaidae	*Bathytanais culteriformis* Larsen & Heard, 2001
	Typhlotanaidae	*Antiplotanais coochimudlo* Bamber, 2008

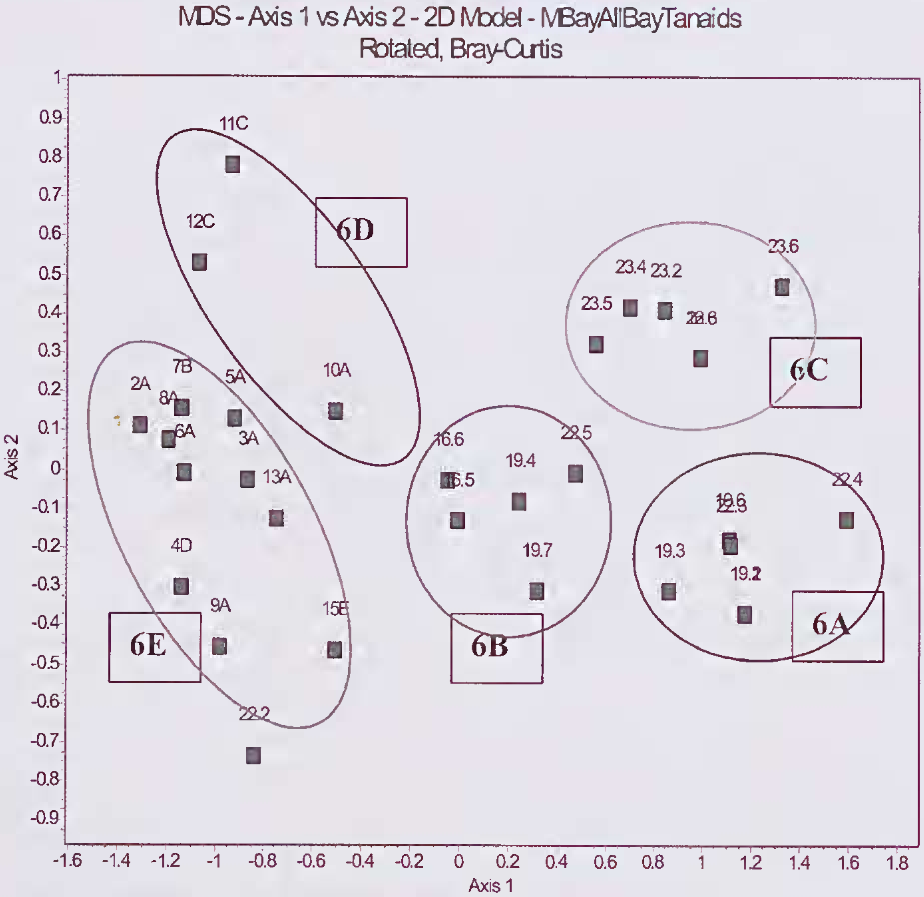

FIG. 7. Species level MDS ordination of Tanaidacea at species level from Fig. 5 (excluding *Gollumudes*/ stn 23.7).

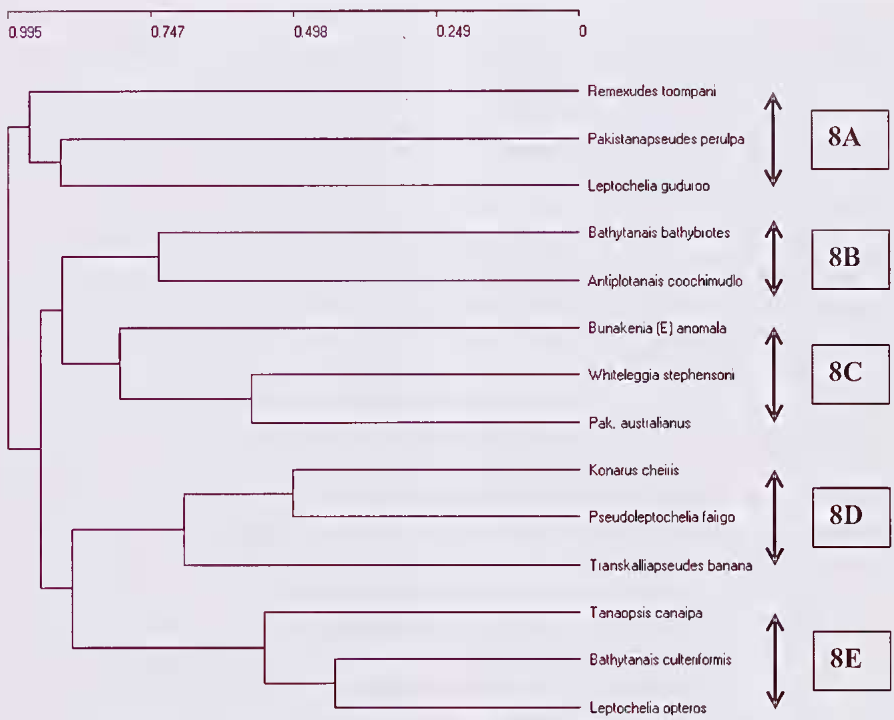

FIG. 8. Clustering of tanaidacean species sampled off Moreton Island.

group E has the majority of stations (11) of the long armed van Veen grab and one 'normal' van Veen grab. The distribution of stations cannot be explained by gear type.

One factor having a major influence on the distribution of macrobenthic assemblages is sediment (e.g. Cranfield *et al.* 2004). We have not undertaken sediment analysis, but noted appearance, see Table 1. The majority of stations have clean medium sand. Group C has only stations with coarse sand, including pebbles and shells. On the other hand, sand with shell breccia also occurs on stations of groups B and E. Only the outlier stations 17.1 and 22.2 contained organic matter, mud and seagrass.

A relationship to sediment would be expected owing to the predominant feeding-association of the taxa concerned. Phoxocephalid amphipods are almost entirely benthic amphipods, and include deposit feeders (Enequist 1949) and predators (Oliver & Slattery 1985). Platyischnopidae are widely distributed benthic infaunal species in shallow waters, closely related to phoxocephalids; Thomas & Barnard (1983) found some species to be micropredators. Urohaustoridae, a family confined to the Southern Hemisphere and mainly to Australia, mostly occur in shallow water and often in the surf zone of oceanic beaches. Synopiids live from subtidal to bathyal depths, may be benthic, demersal or pelagic. Oedicerotids are cosmopolitan amphipods found at all depths, mainly in the benthic infauna; again, Enequist (1949) regarded them as deposit feeders. The parapseudid tanaidaceans are generally under-studied, but again are known to be deposit feeders (e.g. Bamber 2008). The cumaceans are surface-resuspension feeders. All of these benthic taxa are thus dependent upon the sediment, including its granulometry and organic content, for feeding.

The analysis at genus level, restricted to the cumaceans and tanaidaceans, does give further separation of the assemblages within the north of the Bay and down the Pacific coast. As the genera structuring the analysis were represented by single species, discussion of this analysis is deferred to the species-level discussion below. Suffice to say that the assemblage distributions by habitat indicated by the dominant tanaidaceans are also reflected by the cumacean distribution.

When the generic-level analysis, for the tanaidaceans only, is extended to include muddier stations further south within Moreton Bay, and thus including polytypic genera, some confusion is generated. Although the distinctions by depth and substratum are still evident, stations from distinct depth and substrata cluster together, owing to the merging of distinct congeneric species with different habitat preferences.

At the species level, the distinctions of the tanaidaceans relate firstly to the cleaner sand and coastal/offshore sites showing a different community from those sheltered and muddier sites within Moreton Bay itself. The linkage of these predominantly deposit-feeding taxa to the sediment-type is discussed above, being indicated at the family level. Further distinctions are shown at the species level between sea-grass beds and more open substrata. Indeed, analysis of all the tanaidacean species of this region, including a number of taxa not represented in the quantitative samples analysed herein, by Bamber (2008) found a number of examples of intrageneric niche-specification based on substratum and habitat-type. The present analyses confirm those conclusions.

The distinction of different depth ranges at the species level in the tanaidaceans, particularly to the southeast of Morton Island and the northeast of North Stradbroke Island is of further interest. Observation of the seabed samples along the transects off the South Passage between these two islands showed a consistent pattern, with shallower stations appearing to be open clean sand, while deeper stations supported very dense communities of irregular echinoids (heart urchins) and surface-dwelling filter-feeding holothurians (in densities of hundreds per m^2). The distinction between these two sub-habitats was very evident, the shallowest dense appearance of the echinoderms being around 25 m (>28 m on transect 16, thus station 16.5; >25 m on transects 19, thus stations 19.3, 19.4 and 19.7; >26 m on transects 22, thus stations 22.1, 22.2 and 22.5). No samples were taken deeper than 40 m.

We therefore postulate that, during the ebbing tide, the strong seaward flow through the South Passage will carry a large quantity of organic matter and debris from Moreton Bay, in adjacent areas of which occur muddy substrata and seagrass beds; this material will flow down the slope and, as the water velocity decreases, will be deposited onto the seabed. The density of echinoderms, particularly the filter-feeding holothurians, is attributed to this supply of organic material; equally, both the organic material and the holothurians themselves will be structuring the habitat profoundly. These are essentially the stations of group 6B of Figure 6, characterised by *Bathytanais bathybrotes* and many cumacean genera (*Dicoides, Gynodiastylis, Iphinoe* and *Campylaspis*, these last three genera being taken at no other sampling stations). Note that this distinction within the peracarid community does not show at the family level.

These analyses thus indicate that, while analysis at higher taxon levels shows some gross trends in the community distribution, here in relation to substratum, the added detail of species-level analysis affords a more comprehensive, more logical, and explicable interpretation. Past hypotheses that benthic community interpretation is valid at higher taxonomic levels such as family level or even higher ('taxonomic sufficiency'; e.g. Warwick 1988; Mistri & Rossi 2001) are clearly refuted by the present analyses. A more detailed analysis at the species level over a wider taxon base would be expected to reinforce the conclusions shown herein. Nevertheless, these results show that analysis of assemblages of the Peracarida alone does allow interpretation of habitat-associations, and thus biotopes.

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